



INSTRUCTION MANUAL

PTS 160

FREQUENCY SYNTHESIZER

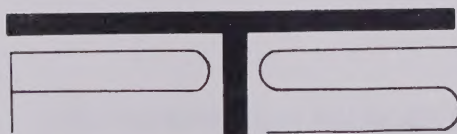
100 KHz - 159 .999 999 9 MHz



PROGRAMMED TEST SOURCES, Inc.



PTS 160 OPERATION MANUAL



PROGRAMMED TEST SOURCES, inc.

Littleton, Massachusetts, USA.

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PROGRAMMED TEST SOURCES, INC.

9 Beaver Brook Road

Littleton, MA 01460

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OPERATION MANUAL

Table of Contents

	Page
Introduction.....	1
Manual Organization.....	1
Specifications.....	2
Installation.....	3
Safety Declarations.....	3
Unpacking.....	4
Dimensions and Weight.....	4
Primary Power.....	4
Bench Use.....	4
Rack Mounting.....	5
Minimum Performance/Incoming Inspection Testing.....	6
Operation.....	8
Power Connection.....	8
Warm-Up.....	8
Internal-External Frequency Standard.....	8
Front Panel Controls.....	8
Rear Panel Controls and Connectors.....	9
Remote Frequency, Signal Level and Control Mode Programming.....	10, 23
Phase Rotation Programming.....	11, 23
Principles of Operation.....	12
General.....	12
Standard Frequency Section.....	12
Fine Resolution Section.....	13
10 MHz Step Section.....	14
Output Amplifier and Level Control.....	15
Service.....	16
General.....	16
System Troubleshooting.....	16
Calibration.....	19
General.....	19
SO-1001 Module Calibration.....	19
10 MHz Internal Frequency Standard Calibration.....	20
Mainframe Components.....	21
Power Supply PS-1019.....	21
Crystal Oscillator OCXO (XT-1012) or TCXO (XT-1013).....	21
Parallel Entry Board PE-1121.....	22
505 MHz Filter 390-1000.....	22
Table 1: PTS 160 Remote Frequency, Signal Level and Control Mode Programming.....	23
Table 2: PTS 160 Phase Rotation Programming.....	23
Table 3: System Troubleshooting.....	24

Table of Contents - continued

	Page
Parts Lists.....	26
Figure 1: Cabinet Dimensions.....	28
Figure 2: Front Panel	29
Figure 3: Rear Panel	30
Figure 4: PTS 160 Block Diagram	31
Figure 5: PTS 160 Test Point Locations.....	32
Figure 6: PTS 160 Module Locations.....	33
Figure 7: PS-1019 Schematic.....	34
Figure 8: PE-1121 Schematic.....	35

Introduction

This manual covers the PTS 160 Frequency Synthesizer and contains information necessary to install, operate and service the instrument.

The PTS 160 is a precision frequency generator. It uses the accuracy and stability of a frequency standard operating at 5.0 or 10.0 MHz, either built-in or external, to produce output frequencies between 0.1 and 159.999 999 9 MHz, with up to 10 significant digits. All output frequencies are coherent with the standard frequency and reflect its stability and accuracy. Any frequency within the above band may be selected by front panel or remote control with resolution as fine as 0.1 Hz. The output from the levelled system is +3 to +13 dBm into 50 ohms and may be adjusted manually by the front panel control or remotely by analog voltage.

The PTS 160 is a direct frequency synthesizer capable of providing signals for many uses requiring stable and accurate sine wave signals with low attendant spurious outputs, low phase noise and fast transfer between selected frequencies. Typical applications include communications, spectrum analysis, surveillance and radar, and automatic test systems with both narrow and wideband coverage.

Manual Organization

The PTS 160 is a complete and integrated system using numerous modules installed on a deck inside the instrument mainframe. All information pertaining to the instrument as a complete system is presented in this Operation Manual. This manual also covers items which are integral parts of the mainframe, such as power supply, front panel, rear panel and crystal oscillator. The GPIB interface, which mounts to the rear panel and replaces the PE-1121 parallel interface, is covered in a separate section.

SPECIFICATIONS

Frequency	Range:	0.100 000 0 MHz to 159.999 999 9 MHz		
	Resolution:	0.1 Hz to 100 KHz, optional in decades		
	Accuracy:	same as frequency standard		
	Control:	manual by 10-position dials; remote by TTL-level parallel entry BCD-encoded negative true logic		
Switching Time		(to within 0.1 radian at new frequency)		
	100 MHz - 10 MHz digits:	20 μ seconds		
	1 MHz - 0.1 Hz digits:	5 μ seconds		
Output	Level:	+3 to +13 dBm (1V max., 50 Ω), metered in dBm and volts (rms)		
	Flatness:	± 0.5 dB		
	Impedance:	50 Ω		
	Control:	manual by front panel control; remote by analog voltage		
Spurious Outputs		(at full power output, +13 dBm)		
	Discrete:	-75 dBc		
	Harmonics:	-35 dBc (-40 dBc at lower power levels)		
	Phase Noise:	-63 dBc (0.5 Hz to 15 KHz, including effects of internal standard)		
	$\mathcal{L}$ (1 Hz):	100 Hz/-105dBc, 1 KHz/-115 dBc, 10 KHz/-123 dBc, 100 KHz/-127 dBc		
	Noise Floor:	-135 dBc/Hz		
Frequency Standard	Internal:	OCXO	or	TCXO
		3 x 10 ⁻⁹ /day		1 x 10 ⁻⁸ /day
		$\pm 1 \times 10^{-8}/0 - 50^{\circ}\text{C}$		$\pm 1 \times 10^{-6}/0 - 50^{\circ}\text{C}$
		1 x 10 ⁻⁶ /year		2 x 10 ⁻⁶ /year
	External:	10.000 MHz, 0.4 - 2.0Vrms into 300 Ω ; 5.000 MHz, 0.5 - 2.0Vrms into 300 Ω		
	Auxiliary Output:	10.000 MHz, 0.4Vrms into 50 Ω		
		Note: internal or external standard required for operation.		
General	Operating Ambient:	0 - 55°C, 95% relative humidity, altitude 0 - 2,000m.		
	Power:	120VAC $\pm 10\%$, 50 - 60 Hz, 40W (100V, 220-230V, 240V optional)		
	IEC Installation category:	II		
	IEC Pollution degree:	2		
	Dimensions:	19 x 5.25 x 18 inches maximum (rack or bench cabinet)		
	Weight:	35 lbs		

For units equipped with a **DDS option**, specifications are modified as follows:

DDS Option		H	J	K
Phase Continuous Switching Range		100 KHz through 0.1 Hz digits	100 KHz through 1 Hz digits	10 KHz through 0.1 Hz digits
Frequency	Resolution:	0.1 Hz	1 Hz	0.1 Hz
	Optional Phase Rotation:	.36° increments, 0 - 360°	.36° increments, 0 - 360°	N/A
Switching Time		(within phase continuous range) < 1 μ s transient, 2 μ s delay		
Spurious Outputs	Discrete:	-65 dBc	-55 dBc	-75 dBc
	Phase Noise:	-63 dBc	-55 dBc	-63 dBc

Installation

CAUTION: Refer to **Primary Power**, page 4, before connecting instrument to line voltage.

Safety Declarations

This product was designed and manufactured in accordance with international safety standards. Before connecting the instrument to line voltage, review all product instructions.

When properly used, this instrument does not present any hazard. Voltages inside this instrument, however, are dangerous and may be fatal. Careless or improper use can lead to accidents; refer to the **Operation** section of this manual before use. Service should be attempted by qualified personnel only; disconnect the power supply before servicing.

If this device is operated outside of its stated specifications, or in a manner not specified, protection provided by the equipment may be impaired.

Safety Symbols



The product will be marked with this symbol when it is necessary for the user to refer to the instruction manual (refer to the **Table of Contents**).



Indicates earth (ground) terminal.

Unpacking

Your instrument has been built, tested and packed carefully and should reach you in perfect mechanical and electrical condition. Please inspect both the carton and the cabinet upon receipt for evidence of damage that might have occurred in transit. In case of damage or defect, a claim must be filed with the carrier immediately.

Dimensions and Weight

Outside cabinet dimensions of the instrument for both the rack and bench versions are given in Figure 1. The weight of the instrument is approximately 35 lbs.

Primary Power

The PTS 160 is designed to operate from power lines with 120 VAC (100, 220-230 or 240 VAC optional), $\pm 10\%$, 50 - 60 Hz. Instrument line voltage is indicated on the rear panel. Instruments equipped with an optional line-voltage capability have a voltage selector switch located on the rear panel (see **Rear Panel Controls and Connectors**, page 9). Instruments without a selector switch require 120 VAC for operation. Before operating your instrument, be certain that it has been connected and fused for your line voltage. Improper connection may lead to damage of the instrument.

Proper grounding of the mainframe to the neutral or ground of the power system is accomplished via a NEMA-approved receptacle and 3-wire power cord in the United States. For the safety of the operator, an approved adapter must be used with 2-wire outlets. This adapter must provide positive connection to the electrical conduit or other low resistance ground. In the European Community, a harmonized line cord with conductor cross section of greater than 0.75 mm², certified by a recognized national body, must be used.

The power consumption of the PTS 160 is approximately 40 watts.

Bench Use

For bench use the PTS 160 is equipped with a fold-down tilt stand. Stacking of the instrument is permissible, provided that air flow for convection cooling of the heat sink on the rear panel is not impaired by deep, overhanging cabinets.

Rack Mounting

The PTS 160 may be mounted to a standard 19 inch relay rack, if ordered with the rack mounting option. Insure that air flow for convection cooling of the heat sink on the rear panel is not impaired. Where shock or vibration are encountered, it is suggested that rear or side supports be provided for the instrument.

Minimum Performance / Incoming Inspection Testing

The following optional minimum performance or incoming inspection tests may be performed to ensure that the instrument is operating correctly. Equipment required to perform these tests is listed below:

Equipment	Recommended Model
Frequency Counter, 0 - 500 MHz	HP 5383A
Power Meter, 0 - 20 dBm	HP 435B/8482A
Spectrum Analyzer, 0 - 500 MHz	HP 8558B/182T

Frequency Verification

- Connect the output of the frequency synthesizer to the input of the counter. Connect the 10 MHz output of the counter (set to INT) to the synthesizer rear-panel 5/10 MHz external frequency standard input, and set the synthesizer rear-panel frequency standard selector switch to EXT STD (see **Rear Panel Controls and Connectors**, page 9, for more information on these connectors).
- Use the front panel or remote control interface to set the synthesizer's output frequency (see **Rear Panel Controls and Connectors**, page 9, for more information on this interface). Check that the synthesizer frequency is correct by observing that the counter reading and synthesizer setting are in agreement at the following frequencies (listed in MHz):

0.100 000 0
0.500 000 0
0.900 000 0
1.000 000 0
11.111 111 1
22.222 222 2
33.333 333 3
44.444 444 4
55.555 555 5
66.666 666 6
77.777 777 7
88.888 888 8
99.999 999 9
100.000 000 0 through 150.000 000 0 in 10 MHz steps
159.876 543 2
159.999 999 9

Output Level Verification

- Connect the probe of the power meter to the output of the synthesizer. If the synthesizer has an internal frequency standard, set the rear-panel frequency standard selector switch to INT STD.
- Set the output frequency to 100 MHz. Check that the output level is +13 dBm ± 0.5 dB.
- Check that the output level does not vary more than a total of 1.0 dB over the entire frequency range (0.1 - 159.999 999 9 MHz) of the synthesizer.

Harmonic and Spurious Outputs Verification

- Connect the output of the synthesizer to the spectrum analyzer input, and set the output level to +13 dBm.
- Make the necessary adjustments on the spectrum analyzer so that the full output spectrum may be observed, making sure that the input is not over driven.
- Check that all harmonics are 35 dB or more below the main output over the entire frequency range (0.1 - 159.999 999 9 MHz) of the synthesizer.
- Check that all spurious outputs are below the specification levels (dependent on model; see **Specifications**, page 2) over the entire frequency range (0.1 - 159.999 999 9 MHz) of the synthesizer.

Frequency Standard Verification (not applicable to instruments with no internal standard)

- Set the rear panel frequency standard selector switch to INT STD, and allow the instrument to warm up for at least 20 minutes.
- Connect the rear panel 10 MHz OUT (frequency standard output) to the input of the counter, which must now be driven from a suitable **calibrated** reference standard.
- Check that the measured frequency is 10 MHz ± 2 Hz. If adjustment is necessary, follow the procedure detailed in **10 MHz Internal Frequency Standard Calibration**, page 20.

Operation

Power Connection

Before attempting to connect the instrument to the primary power, verify proper line voltage connection and fusing (see **Primary Power**, page 4).

Warm-Up

The PTS 160 is operative on turn-on. If the instrument is equipped with an oven-type crystal oscillator, a period of 20 minutes is required at 25°C ambient for the frequency to be within $\pm 1 \times 10^{-7}$ of nominal. In general, it is desirable to operate the equipment continuously for best frequency stability.

Internal-External Frequency Standard

The synthesizer may be operated from either the internal or an external frequency standard (5.0 or 10.0 MHz). For internal standard operation, the frequency standard selector switch (rear panel) must be set to INT STD; for external standard operation, the switch must be set to EXT STD. Note that for internal standard operation, the switch **must** be set to INT STD even if no external standard is connected; otherwise, no output is generated.

Front Panel Controls

Figure 2 identifies all controls provided on the front panel for local operation.

- (a) *Frequency Selector Switches with Dial* - Rotary switches control the 100 MHz through 0.1 Hz digits. The highest output frequency obtainable from the PTS 160 is 159.999 999 9 MHz.
- (b) *Local/Remote Indicators* - LEDs indicate the mode in which the instrument is operated. The remote mode is enabled via the program connector on the rear panel; manual dial settings indicate frequency only when operating in the local mode. See also **Rear Panel Controls and Connectors**, page 9.
- (c) *Level* - Continuously variable control to set output signal to desired level between +3 dBm and +13 dBm into 50 ohms, with the aid of the meter. The fully counter-clockwise (ccw) position disconnects this control for remote level settings.

- (d) *Meter* - The meter indicates voltage and power in dBm delivered into a 50 ohm load. Voltage behind a 50 ohm source resistor is monitored, and the meter indicates one-half of this value. Calibration is valid for 50 ohm loads only.
- (e) *Output Connector* - BNC jack supplies instrument main output.
- (f) *Power Switch* - The primary power to the instrument is controlled by this switch. Local/Remote LED indicators also serve as line-power indicators.

With these controls, any frequency between 100 KHz and 159.999 999 9 MHz may be selected. When power output of less than +3 dBm is desired the use of 50 ohm attenuators is recommended.

Rear Panel Controls and Connectors

Figure 3 shows rear panel controls and connectors for frequency, signal level and control mode programming and auxiliary inputs and outputs.

- (a) *3-Wire Primary Power Cord Receptacle* - Accepts power cord for instrument operation.
- (b) *Fuse Holders* - Fuse rating and primary supply voltage for the instrument are indicated beside the fuse holders.
- (c) *Optional Location for Instrument Main Output Connector* - If this connector is present, any front panel output connector is inactive.
- (d) *5/10 MHz External Frequency Standard Input* - Accepts an external frequency standard of either 5.0 or 10.0 MHz, 0.4 - 2.0V into 300 ohms to control instrument. **Important:** see also *Frequency Standard Selector Switch*, below.
- (e) *Frequency Standard Selector Switch* - Slide switch which selects between an internal or external frequency standard. This switch **must** be set to INT STD if no external frequency standard is provided.
- (f) *10 MHz Standard Frequency Output* - 10.0 MHz, 0.4V into 50 ohm output which may be used to drive other synthesizers without internal standards as *slaves*.
- (g) *Remote Programming Connector* - Amphenol 57-40500 connector which requires 57-30500 connector for control. This connector provides remote frequency, signal level and mode control programming. All functions employ negative true programming logic; with no connector attached, all functions are in a default off or false state. All functions connect directly to 74-type ICs. Connection to ground will enable all functions. To set the instrument to the local mode for front panel control, either remove any attached 57-30500 connector or make certain that pin 42 is high. A complete pin-out of this

connector is given in Table 1. See also **Remote Frequency, Signal Level and Control Mode Programming**, below.

- (h) *Access Hole for Output Level Control* - Access to potentiometer for adjusting default output level for remote-control operation.
- (i) *Optional Line Voltage Selector Switch* - Selects optional line voltage for instrument operation.

Remote Frequency, Signal Level and Control Mode Programming

The output frequency, output signal level or amplitude, and the mode of control (local or remote) are all remotely programmable through the Amphenol 57-type connector located on the rear panel. Table 1 lists the pin assignments for the 57-40500 connector. Output signal level programming is analog DC voltage level-controlled; all other programming on this connector is level (or state) triggered and employs TTL-level **negative** true logic.

The programming format for frequency control is parallel entry, 4 bit (1, 2, 4, 8 weighting) for all digits. No programming is performed on the 100 MHz digit; instead, the 10 MHz digit is programmed via a **hexadecimal** code to a digit between 0 and 15, corresponding to a setting of **0 x 10 MHz** through **15 x 10 MHz**. (i.e., **0 MHz** through **150 MHz**). For all other digits, 4 bit **BCD** coding is employed (1, 2, 4, 8 weighting, encoding digits 0 - 9 only). By default, all frequency programming pins are internally pulled to a high (false) state; to program a specific frequency the appropriate pins must be brought to the low state.

For the 0.1 Hz through 1 MHz digits, remote frequency programming changes result in an output signal at the new frequency (within 0.1 radian) within 5μseconds; for the 10 MHz and 100 MHz digits, frequency changes are effected within 20 μseconds.

Data latches are included which provide storage when a "latched" mode of operation is required. By default, all Latch Enable (LE) pins are internally pulled to a high (false) state, disabling the latches. To store remote frequency programming input, the LE pins must be brought to the low state. To accept new remote frequency programming input, the LE pins must be returned to the high state. To operate in a "transparent" (i.e., non-latched) mode, the LE pins may be left unconnected, or must be placed in the high state. A separate latch enable line is provided for each pair of digits so that serial operation with separate frequency programming data bytes is possible. Table 1 also lists the LE pin assignments.

Output level programming is by analog voltage, with a default output level set by a rear-panel accessible 10K ohm potentiometer (see **Rear Panel Controls and Connectors**, page 9). The default output level can be set to any valid level in the instrument's output range of +3 to +13 dBm. To enable remote amplitude programming, the user must provide a DC analog voltage from a low-impedance source on pin 22 of the remote interface, which will override the 10K ohm potentiometer default setting. The RMS output signal level is one-half (0.5) of the DC analog voltage present. The valid input voltage range is 0.6 - 2.0 VDC corresponding to an output signal level range of 0.3 - 1.0 Vrms into 50 ohms (+3 - +13 dBm).

The mode of frequency control, local or remote, is remotely programmable through the Remote Enable pin 42. By default this pin is internally pulled to a high (false) state; to enable the remote mode pin 42 must be brought to a low (true) state. If it is desired to go to remote frequency programming, but to do this under local control, a switch should be installed between pin 42 and ground.

See also **Parallel Entry Board PE-1121**, page 22.

Phase Rotation Programming

Instruments may also be equipped with optional phase rotation, with resolution of 0.36°.

Phase rotation is programmed through a separate 15 pin D-type connector located on the rear panel; Table 2 lists the pin assignments. Programming on this connector employs the same TTL-level **negative** true logic and BCD coding as described under **Remote Frequency, Signal Level and Control Mode Programming**, page 10. In addition, the same "latched" and "transparent" modes of operation are available; Table 2 also lists the LE pin assignments. By default, all pins are internally pulled to a high (false) state, corresponding to 0° phase rotation. To program a specific phase rotation, the appropriate pins must be brought to the low (true) state.

Principles of Operation

General

An overview of the system is presented in this section by discussing the block diagram in Figure 4. Figures 5 and 6 show the location of the modules discussed. The material presented here is essential for efficient service, and familiarity with it is assumed in the service instructions.

All output frequencies of the PTS 160 are derived from the crystal oscillator by arithmetic operations and are fully coherent with the 10 MHz reference frequency. The instrument uses a simplified direct synthesis in which all auxiliary fixed frequencies are produced from a 10 MHz pulse. The final output frequency comes from a beat-frequency system as follows:

A signal of 355 to 365 MHz, which carries all 0.1 Hz to 1 MHz steps, is subtracted from a 365 to 515 MHz signal, which carries the 10 MHz steps. The resultant output ranges from 0.1 MHz to 159.999 999 9 MHz. The 0.1 MHz is the practical cutoff in the output amplifier; lower frequencies could otherwise be obtained.

The block diagram shows a crystal oscillator (which is the prime reference in the system) and four sections: a Standard Frequency Section, a Fine Resolution Section, a 10 MHz Step Section, and an Output Section.

Standard Frequency Section

This section consists of the SGA and SGB (Standard Generator type A and B) modules. Operating from an input of 10.000 MHz (or an automatically doubled 5.000 MHz input), the module provides all fixed standard frequencies used in the instrument.

The filtered 10 MHz signal is fed to a pulse generator, where harmonics of 20 MHz through 140 MHz are generated with equal amplitude. This "picket fence" is the basis for all standard frequencies. Through arithmetic operations on this picket fence, the SGA and SGB modules generate 14, 16, 18, 20, 22, 112 and 113 MHz for use in the fine resolution section. The 10 MHz picket fence (10 - 140 MHz) from the SGA is also supplied to the 10 MHz step section.

Fine Resolution Section

This section may contain up to 7 DM (Digit) modules (0.1 Hz through 100 KHz steps), and most of the synthesis process is accomplished in these repetitive modules which are identical in design. They operate in series, with the output of a lower-order DM module feeding the input of the next higher-order DM module. The DMA (Digit Type A) module is also included in this section because it is nearly identical to the DM modules in design and function. The DMA module produces the 1 MHz step. These modules all use 14, 16, 18, 20, 22, 112 and 113 MHz.

The function of the series-connected DM modules is to produce frequency increments on a 14 MHz *carrier* in accordance with the dial settings (or remote programming) of the 0.1 Hz through 100 KHz steps. For example, if a frequency of 0.543 210 0 MHz has been selected for these digits, the output of the final DM module which feeds the DMA module is 14.543 210 0 MHz.

For some models, this section alternately consists of a DDS (Direct Digital Synthesizer) and UC (Up-Converter) module replacing up to 7 DM modules. The function of the DDS module is to produce frequency increments on a 2 MHz *carrier* in accordance with the remote programming for the 0.1 Hz through 100 KHz steps. The function of the UC module is to then shift this signal to a 14 MHz carrier suitable for input to a DM module (for improved spurious performance), or for input directly to the DMA module (for wideband DDS coverage).

As an example, if a frequency of 0.543 210 0 MHz has been selected for the 0.1 Hz through 100 KHz digits, the output of the DDS module will be 2.543 210 0 MHz, and the output of the UC module will be 14.543 210 0 MHz.

The block diagram shows a standard configuration of DM modules feeding the DMA module. For instruments which include a DDS with improved-spurious performance (resolution option K instruments), the block diagram identifies point 'A', where the UC module output will feed the single succeeding DM module. For instruments with wide-band DDS coverage (resolution option H or J), the block diagram identifies point 'B', where the UC module output will directly feed the DMA module.

The DMA module adds the 1 MHz step and also transfers the information to a frequency which can more readily carry a 10 MHz bandwidth. The module accepts the 14 - 15 MHz low-resolution carrier from the previous module, adds the 1 MHz step, and transfers this information to a 140 MHz

carrier frequency. If the above example is expanded to include a setting of 6.543 210 0 MHz for the 1 MHz through 0.1 Hz steps, then the output of the DMA module is 146.543 210 0 MHz.

10 MHz Step Section

This section consists of the IM (Intermediate Mix) module, the SO (Stepped Oscillator) module, and the 505 MHz cavity filter. In this section, frequencies are used which are not derived from the frequency standard. Frequencies mentioned in previous paragraphs were all as accurate as the 10 MHz reference frequency. Here, however, the VCO frequencies from 365 to 515 MHz (in 10 MHz steps) may differ from their nominal values by as much as 1 MHz. As explained below, such deviation from nominal values has no effect on the accuracy of the final output frequency. The Stepped Oscillator operates in a drift-cancelled loop which serves two functions:

1. Selection and filtering of one of fourteen 10 MHz pickets by a fixed 505 MHz filter.
2. Supply of frequencies high enough for the final mixer, with a high degree of coherence in the two mixer inputs.

The block diagram lists VCO frequencies corresponding to selected 10 MHz steps as examples. These will be helpful in understanding the complete synthesis process via the sample frequency.

Continuing with the sample frequency of the previous sections, and assuming that the 10 MHz dial has been set to 10, the complete frequency setting is 106.543 210 0 MHz. As listed in the block diagram, for a dial setting of 10 the VCO will produce a frequency of 465 MHz, which is fed to two different mixers. In the SO module picket fence mixer, the picket fence frequency of 40 MHz will add to the 465 MHz and feed 505 MHz through the filter and into the IM module. In the IM module, the 505 MHz is mixed with the 146.543 210 0 MHz output of the 1 MHz step section. A 355 to 365 MHz bandpass filter at the top of the IM module selects the lower sideband of this mix; for the current example, the selected frequency is 358.456 790 0 MHz. The selected frequency is then fed to the SO module final output mixer, where it is mixed with the VCO frequency of 465 MHz. A low-pass filter selects the resultant difference of 106.543 210 0 MHz, the desired output frequency.

As can be seen, the VCO feeds both inputs to the final output mixer, one directly and the other after an intermediate mix. Therefore, if the VCO frequency deviates from nominal, *both* mixer inputs deviate from nominal by the *same* increment. This obviously does not alter the difference between these two frequencies, which is the desired output frequency.

Output Amplifier and Level Control

The final output from the 10 MHz Step Section is a low-level signal in the 0.1 - 159.999 999 9 MHz frequency range. The OA (Output Amplifier) module provides any necessary filtering, wideband gain and levelling-control of amplitude to produce instrument outputs up to +13 dBm across the band from a 50 ohm source-impedance with substantially flat response.

Service

CAUTION: When properly used, this instrument does not present any hazard. Voltages inside this instrument, however, are dangerous and may be fatal. Careless or improper use can lead to accidents. Disconnect power supply before opening; service by qualified personnel only!

General

In general, no preventive maintenance is required for the PTS 160. Minor recalibration of the instrument may be performed annually as described in the **Calibration** section, page 19.

Unless used in an abnormally dusty environment, no cleaning of this instrument is required.

The PTS 160 contains no user-serviceable parts. Should the instrument require service, the **System Troubleshooting** section provides information which permits identification of a defective module. In the case of malfunction, all modules are easily removed from the deck and replaced; defective modules must then be returned to the factory for service.

System Troubleshooting

EXTREMELY IMPORTANT!

For operation, the unit **must** be driven from either an internal or external 5 or 10 MHz frequency standard, and the Frequency Standard Selector Switch set to INT STD or EXT STD, accordingly (see **Rear Panel Controls and Connectors**, page 9). After verifying that a frequency standard is correctly connected and/or selected, if no instrument output is present, proceed as described below.

The following test equipment is recommended for troubleshooting:

RF-Voltmeter V	1 - 500 MHz, 10 mV - 1V, high impedance probe (3 pF, DC resistance 100K Ω)
HF-Counter C	0 - 500 MHz or 0 - 150 MHz, 10 mV sensitivity, high impedance or 50 Ω input, 1 Hz resolution; input for External Drive for synchronization with 10 MHz standard, 0.5V into 50 Ω
Spectrum Analyzer SA	10 - 500 MHz, 50 Ω input; min. 60 dB on-screen dynamic range; max. BW 1 MHz; min. sensitivity - 40 dBm
Multimeter	Analog or digital; 0-15V, 0.1V resolution; 0-2A, 0.1A resolution

Test equipment is referred to in Table 3 as noted above (V, C, SA). The Voltmeter and Counter must have high DC input resistance since connection is made to points with +5.4V potential. The RF-Voltmeter probe connects directly to test points. The Counter is connected via an RG 174 or similar cable equipped with small alligator clips. The Spectrum Analyzer is connected via a cable equipped with an SMA male connector and via a high impedance 500 Ω (10X) probe.

NOTE

Either the 5/10 MHz input or the 10 MHz output can be used to synchronize the Counter in the troubleshooting of an instrument. For **complete** correspondence of front panel or remote control settings and counter readings, synchronization is **required**; otherwise, any differences between the two frequency standards will result in differences between settings and readings.

Connect the instrument to the AC power line. For instruments equipped with front panel controls, turn the power switch to the ON position. Check the AC power line fuses if no RF output is obtained. Use only a fuse of the proper rating as a replacement. If AC line power is present, set a test frequency either by front panel or remote control (see **Operation**, page 8).

If no output is obtained, check the rear panel 10 MHz OUT. A 10 MHz, 0.4V output should be obtained. If no 10 MHz signal is present, insure that a 5 or 10 MHz frequency standard has been properly connected and/or selected. For instruments operating on an internal frequency standard, set the Frequency Standard Selector Switch to EXT STD and connect an external 5 or 10 MHz frequency standard; if the instrument now functions properly, the internal frequency standard is defective and must be replaced.

If, after these steps, the instrument still does not operate properly, the instrument's top and bottom covers must be removed for further testing. Disconnect the unit from the power line; remove the screws attaching the covers, and carefully withdraw them.

After the unit is again powered, check for the presence of supply voltages -12.4V (blue wire) and +5.4V (green wire) at the terminals of the power supply on the rear panel. If voltages are within $\pm 0.2V$, proceed to the next step; if voltages are absent or low, measure current in the leads from the power supplies. The proper 12.4V current is 0.8 - 1.0A (dependent on the crystal oven temperature); the proper 5.4V current is 1.0 - 1.25A. Improper or missing currents indicate a faulty power supply, or a short or overload within the instrument.

If a fault is localized to a particular decade (e.g., all 100 KHz steps defective), or to a particular bit within a decade (e.g., 1 bit defective in the 100 KHz decade, resulting in only even 100 KHz steps), perform a careful DC voltage and continuity check of the related control signal wiring and processing with the aid of the following functional descriptions and schematics:

- **Parallel Entry Board PE-1121**, page 22
- **Figure 4: PTS 160 Block Diagram**, page 31
- **Figure 8: PE-1121 Schematic**, page 35

Insure that valid TTL-level positive-true control signals are delivered to all related synthesis modules.

Assuming that proper supply voltages are present and that wiring and logic IC faults on the PE-1121 module have been eliminated, the tests described in Table 3 will identify a defective module. Table 3 lists test points and expected signal frequencies and levels; Figure 5: PTS 160 Test Point Locations and Figure 6: PTS 160 Module Locations show the location of the test points.

To perform a full diagnostic check, all test instruments with the upper frequency limits are required. However, it is possible to complete some tests of the instrument with the RF-Voltmeter and the 150 MHz Counter. Proceeding from the crystal oscillator, through the Standard Frequency Section and the Fine Resolution Section, most tests for presence of signal and proper frequency can be made *bridging*, without opening connections. Tests of these sections will cover most of the instrument. To test the 10 MHz Step Section and the Output Section, 50 ohm SMA connections must be made.

Calibration

General

In general, no preventive maintenance is required for the PTS 160. The presence of an output signal of the correct frequency indicates that the instrument is functioning properly. To offset the effects of aging and insure uninterrupted proper instrument operation, minor recalibration of the SO-1001 module may be performed annually; the **SO-1001 Module Calibration** section below provides the information necessary to perform this.

For instruments equipped with an optional internal 10 MHz frequency standard, recalibration of the frequency standard should be performed on a schedule dictated by the user's accuracy requirements and the specified drift characteristics of the optional frequency standard; see **Crystal Oscillator OCXO (XT-1012) or TCXO (XT-1013)**, page 21 and **10 MHz Internal Frequency Standard Calibration**, page 20.

SO-1001 Module Calibration

Over long periods of time, minor recalibration of the SO-1001 module may become necessary due to aging of the module's tuned circuits. The 10 MHz steps of the SO-1001 module (365 to 515 MHz) must be within ± 1.0 MHz for proper operation of the instrument. **However, since the SO-1001 module operates inside a drift-cancelled loop, any frequency errors within ± 1.0 MHz do not affect the overall accuracy of the output frequency;** see **Principles of Operation**, page 12.

The following adjustments assume familiarity with the procedures described in **System Troubleshooting**, page 16. For these adjustments, the instrument **must** be at operating temperature after having warmed up for at least 3 hours. After warm-up, remove the instrument's top and bottom covers. Pots for the adjustment of all 10 MHz steps are accessible after removing the aluminum tape over the slots on the top of the SO module. Oriented from the front of the unit, step 0 corresponds to the front-most pot (closest to the front of the instrument), step 1 to the adjacent pot, and so on through step 15, the back-most pot.

Step 19 of the troubleshooting procedure (see Table 3: System Troubleshooting) allows the measurement of a 365 MHz IF frequency generated by all 10 MHz steps. With the 1 MHz through 0.1 Hz digits remotely programmed to zero, proceed through all 10 MHz steps (16 steps, 0 - 150

MHz), observing the frequency on the Counter. For each step, adjust the appropriate pot so that the Counter reading is $365 \text{ MHz} \pm 0.2 \text{ MHz}$. In general, it is necessary for aluminum shielding tape to cover pots not being adjusted (i.e., uncover the pots corresponding to the first five steps, but leave the remainder of the tape in place; after completing the first five steps, replace the tape and proceed to the next five steps). After completing all steps, be sure that aluminum shielding tape covers all slot openings.

10 MHz Internal Frequency Standard Calibration

For instruments equipped with an internal TCXO or OCXO frequency standard, calibration of the standard at periodic intervals may be necessary due to normal aging of the standard's quartz crystal. All quartz crystal oscillators are secondary standards which require a primary reference for calibration. PTS oscillators are set to within 1×10^{-7} of nominal at the time of delivery from the factory. Thereafter, these oscillators are subject to the time-drift and temperature-drift given in the specifications (see **Crystal Oscillator OCXO (XT-1012) or TCXO (XT-1013)**, page 21. A suitable recalibration interval must be determined by the user, and should take into account the accuracy requirements of the user's particular application, and the drift specifications of the oscillator supplied with the instrument.

For this adjustment, the instrument **must** be at operating temperature after having warmed up for at least 3 hours. After warm-up, **without** disconnecting or turning off the primary power, remove the instrument's top cover. Each type of oscillator includes a potentiometer for frequency adjustment which is accessible from the top of the oscillator. In the case of the TCXO, it is located under aluminum shielding tape; for the OCXO, it is beneath a screw-cover; remove the adjustment-pot cover.

Connect the rear panel 10 MHz OUT (frequency standard output) to the input of a frequency counter driven from a **suitable primary reference standard**. Insure that the rear panel Frequency Standard Selector Switch is set to INT STD. Carefully adjust the internal standard's frequency so that the counted frequency reads $10 \text{ MHz} \pm 1 \text{ Hz}$. After completing the adjustment, reinstall the adjustment-pot cover, and carefully reinstall the instrument top cover.

Mainframe Components

Power Supply PS-1019

The PS-1019 board, operating from commercial power lines, generates DC voltages of +5.4V and -12.4V. The +5.4V is used for TTL and MECL logic (fed by decoupling networks), and the -12.4V powers transistor amplifiers. Maximum current is 2.0A at +5.4V and 1.5A at -12.4V, approximately.

Both regulators operate from capacitor input filters, fed by silicon rectifier bridges. The series-pass transistor, gain and reference elements are integrated in a TO-3 package which is heat-sunk to the rear panel. Both supplies are short-circuit proof with fold-back current limiting.

The transformer uses paralleled primaries for 120V input or optional switch-selectable 100V, 220-230V and 240V inputs.

In case of malfunction, refer to the schematic (Figure 7: PS-1019 Schematic) which lists essential DC voltages for both supplies to locate the faulty component or replace the supply-board as a unit.

Crystal Oscillator OCXO (XT-1012) or TCXO (XT-1013)

The PTS 160 may be supplied with a built-in OCXO (XT-1012) or TCXO (XT-1013) crystal oscillator operating at 10 MHz. If installed, it is mounted on the instrument deck and has the following characteristics:

Type:	OCXO (XT-1012)	TCXO (XT-1013)
Frequency:	10.000 000 MHz	
Aging:	3×10^{-9} / day 1×10^{-6} / year	1×10^{-8} / day 2×10^{-6} / year
Temperature Coefficient:	$\pm 2 \times 10^{-10}$ / °C	$\pm 2 \times 10^{-8}$ / °C
Output:	1Vrms into 500 Ω	1Vrms into 500 Ω
Warm-Up Time:	24 hrs for 1×10^{-8}	-
DC Supply:	-12.4V, 250 mA (500 mA turn-on)	-12.4V, 20 mA

Both oscillators have provision for adjustment to compensate for long-term drift.

Parallel Entry Board PE-1121

The PE-1121 board contains circuitry to interface remote programming signals for frequency, output signal level and control mode (remote or local) with the appropriate modules within the instrument. The board is mounted to the rear of the unit, and is directly connected with an Amphenol 57-type input connector. Table 1 lists pin assignments for the 57-40500 connector.

All functions connect directly to 74-type ICs, and use TTL level, negative true logic. By default, all logic control pins are internally pulled to a *high* (false) state. The programming format for frequency control is parallel entry 4 bit BCD (1, 2, 4, 8 weighting) for each digit. 74HCT533 latches provide storage when a *latched* mode of operation is desired. To store remote frequency programming input, the Latch Enable pins must be brought to the *low* state. The output signal level is remotely controlled through a DC analog voltage on pin 22, with the RMS output voltage (into 50 ohm) set at one-half (0.5) the DC level. The remote/local mode is remotely programmed through pin 42. With reference to Figure 8, U6 is used to control a switch consisting of two transistors. U6 accepts the remote enable signal, which is negative true. In the local mode, latches are set to the *off* (third) state, and 5.1V is supplied to the front panel.

See also **Remote Frequency, Signal Level and Control Mode Programming**, page 10.

505 MHz Filter 390-1000

The 505 MHz multi-pole filter forms part of the 10 MHz step section. It is fixed-tuned and cannot be retuned in the field. The 390-1000 is bolted to the instrument deck.

TABLE 1: PTS 160 REMOTE FREQUENCY, SIGNAL LEVEL AND CONTROL MODE PROGRAMMING

Amphenol 57-40500 - On Equipment
Amphenol 57-30500 - Required to Control

Hex / BCD Weight:		1	2	4	8	Latch Enable
Digit		Pin Numbers				
10 MHz	(0-15, Hexadecimal valid)	15	16	40	41	23
1 MHz		17	18	19	20	24
100 KHz		1	2	26	27	24
10 KHz		3	4	28	29	25
1 KHz	(0 - 9 BCD valid;	5	6	30	31	25
100 Hz	10 - 15 invalid)	7	8	32	33	46
10 Hz		9	10	34	35	46
1 Hz		11	12	36	37	47
0.1 Hz		13	14	38	39	47

Frequency and Control Mode Programming

Frequency and Control Mode programming employ TTL-level, **negative** true logic.

Remote Enable = Pin 42

+5 - +5.4V = Pin 48 (100 mA max)

Ground = Pin 50

Signal Level Programming

Output signal level programming is through analog DC control voltage on Pin 22.

Remote Level = Pin 22

RMS output = 0.5 x Pin 22 DC control voltage, +0.6 - +2.0 VDC

Ground = Pin 21

TABLE 2: PTS 160 PHASE ROTATION PROGRAMMING

15 pin D-type female connector - On Equipment (OPTIONAL)

15 pin D-type male connector - Required to Control

BCD Weight:		1	2	4	8	Latch Enable
Phase Increment		Pin Numbers				
36.0°	(0 - 9 BCD valid)	9	10	11	12	14
3.60°	(0 - 9 BCD valid)	5	6	7	8	15
0.36°	(0 - 9 BCD valid)	1	2	3	4	15

Phase Rotation programming employs TTL-level, **negative** true logic.

Ground = Pin 13

TTL Levels

Low: +0.7V max

High: +2.0V min

TABLE 3: SYSTEM TROUBLESHOOTING

Step	Test Point	Frequency (MHz)	Level	Test Equipment	Module Checked	Notes
1	SGA, 51	10.000	0.4V	V, C	Freq. Std.	
2	SGA, 49	10.000	0.4V	V, C	SGA	
3	SGA, 20	18.000	0.1V	V, C	SGA	
4	SGA, 43	20.000	0.1V	V, C	SGA	
5	SGA, 6	22.000	0.1V	V, C	SGA	
6	SGA, 2	33.000	90mV	V, C	SGA	
7	SO, J1	10-140	-17 dBm	SA	SGA	1
8	SGB, 10	14.000	0.1V	V, C	SGB	
9	SGB, 24	16.000	0.1V	V, C	SGB	
10	DS, 50	10.000	0.4V	V, C	SGA	2
11	DS, 3	2 - 3	0.22V	V, C	DS	3
12	UC, 46	10-140	-17 dBm	SA	SGA	4
13	UC, 50	14 - 15	0.2-0.3V	V, C	UC	3
14	DM, 50 (all)	14 - 15	0.2-0.3V	V, C	DM	5
15	DMA, 1	112.000	0.1V	V, C	SGB	6
16	DMA, 10	113.000	0.1V	V, C	SGB	7
17	DMA, 50	140.000	0.4V	V, C	DMA	8
18	FILTER OUTPUT	505 $\pm$ 1	-35 dBm	SA	SO, Filter	9
19	IM, J3	365 $\pm$ 1	-16 dBm	C	IM	10
20	SO, J3	1 - 159	-30 dBm	SA	SO	11
21	OA, J1	100.000	+13 dBm	SA	OA	6
22	OA, J1	0.1 - 159	+13 dBm	SA	OA, full band	12

Test point designations show the module and pin number (position) on the board-edge connector, as used in Figure 5.

Notes:

1. Open SMA connection at SO, J1. Connect SA to disconnected cable in place of SO, J1. Each 10 MHz multiple from 10 to 140 MHz to be displayed.
2. **Applicable to instruments with DDS option H, J or K only.**
3. **Applicable to instruments with DDS option H, J or K only.**
Set the instrument to 100.000 000 0 MHz, +13 dBm output level.
DDS Option H or J: Set and test all 100 KHz through 0.1 Hz steps (10 steps, 0 - 9 for each decade). At each step, there must be complete correspondence between the 100 KHz through 0.1 Hz digits set and the 100 KHz through 0.1 Hz frequency increments of the test point frequency.
DDS Option K: Set and test all 10 KHz through 0.1 Hz steps (10 steps, 0 - 9 for each decade). At each step, there must be complete correspondence between the 10 KHz through 0.1 Hz digits set and the 100 KHz through 1 Hz frequency increments of the test point frequency, i.e., 10 KHz setting must correspond to 100 KHz frequency offset of test point frequency, 1 KHz setting must correspond to 10 KHz offset of test point frequency, etc.
4. Each 10 MHz multiple from 10 to 140 MHz to be displayed.
5. **Not applicable to instruments with DDS option H or J.**
Set the instrument to 100.000 000 0 MHz, +13 dBm output level.
For each DM module present, set and test applicable decade of resolution at all ten steps (0 - 9). At each step, there must be complete correspondence between digit set and 100 KHz frequency increment of the test point frequency.

**TABLE 3: SYSTEM TROUBLESHOOTING
(continued)**

Notes: (continued)

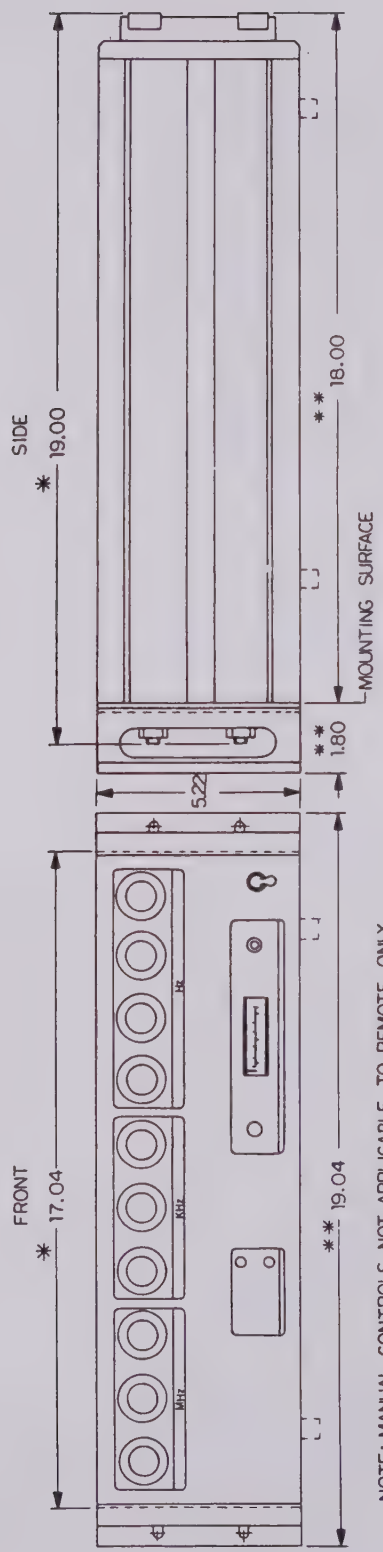
6. Set the instrument to 100.000 000 0 MHz, +13 dBm output level.
7. Set the instrument to 101.000 000 0 MHz, +13 dBm output level.
8. Program 1 MHz decade through successive steps 0 to 9; test point frequency must increase in 1 MHz increments from 140.000 MHz to 149.000 MHz. Return instrument to 100.000 000 0 MHz setting before proceeding to next test.
9. Program 100 MHz and 10 MHz decades through 16 successive 10 MHz steps 0 - 150 MHz.
10. Program 100 MHz and 10 MHz decades through 16 successive 10 MHz steps 0 - 150 MHz. At each 10 MHz step, program 1 MHz decade through successive steps 0 to 9; test point frequency must decrease in 1 MHz increments from 365.000 MHz to 356.000 MHz.
11. Set 1 MHz decade to 1 MHz. Program 100 MHz and 10 MHz decades through 16 successive 10 MHz steps 0 - 150 MHz; test point frequency must increase in 10 MHz increments from 1.0 MHz to 151.0 MHz. At step 16 (151 MHz), set 1 MHz decade to 9 MHz; test point frequency must increase to 159.0 MHz.
12. Set and test instrument over the frequency range indicated.

PS-1019 PARTS LIST

Schematic Designation	Description	PTS P/N
CAPACITORS		
C1	10,000 μ F, 25V	31-5106
C2	15 μ F, 20V	30-5105
C3	6.8 μ F, 25V	30-5101
C4	10,000 μ F, 25V	31-5106
C5 - C6	6.8 μ F, 25V	30-5101
RESISTORS		
R1	1.91K Ω , 1%, .25W	14-5115
R2	243 Ω , 1%, .25W	14-5105
R3	500 Ω , Pot., 10%, .75W	17-5103
R4	715 Ω , 1%, .25W	14-5127
R5	243 Ω , 1%, .25W	14-5105
R6	200 Ω , Pot., 10%, .75W	17-5105
DIODES		
CR1 - CR8	3A, 100V	74-5100
INTEGRATED CIRCUITS		
U1 - U2	LM350K	64-0350K
TRANSFORMERS		
T1	50-400 Hz	83-5102

PE-1121 PARTS LIST

Schematic Designation	Description	PTS P/N
CAPACITORS		
C1 - C7	50 nF, 80/20%, 50V, Z5V	23-0503
C8	6.8 μ F, 25V	30-5101
RESISTORS		
R1 - R2	2.2 Ω , 5%, .25W	11-1220
R3	10K Ω , Pot., 10%, .50W (For remote-only units)	16-5101
R4	4.7K Ω , 5%, .25W	11-0472
R5	1.0K Ω , 5%, .25W	11-0102
R6	4.7K Ω , 5%, .25W	11-0472
R7	2.2K Ω , 5%, .25W	11-0222
R8 - R10	2.2K Ω , 5%, .25W (optional attenuator)	11-0222
R11	680 Ω , 5%, .25W (optional attenuator)	11-0681
A1 - A9	Resistor Network, 2.2K Ω , 2%	66-5002
TRANSISTORS		
Q1 - Q2	2N2905	42-2905
INTEGRATED CIRCUITS		
U1 - U6	74HCT533	61-5029
U7	74LS05	63-0005
CONNECTORS		
J1	50 pos. conn. (series 57 compatible)	78-1000
J2	50 pos. conn. (optional)	78-1000
P1	53 pin header strip from 2 @ 26 pin	79-1003
P2	4 pin header strip from 1 @ 26 pin	79-1003



NOTE: MANUAL CONTROLS NOT APPLICABLE TO REMOTE-ONLY UNITS, WHICH HAVE A BLANK FRONT PANEL.

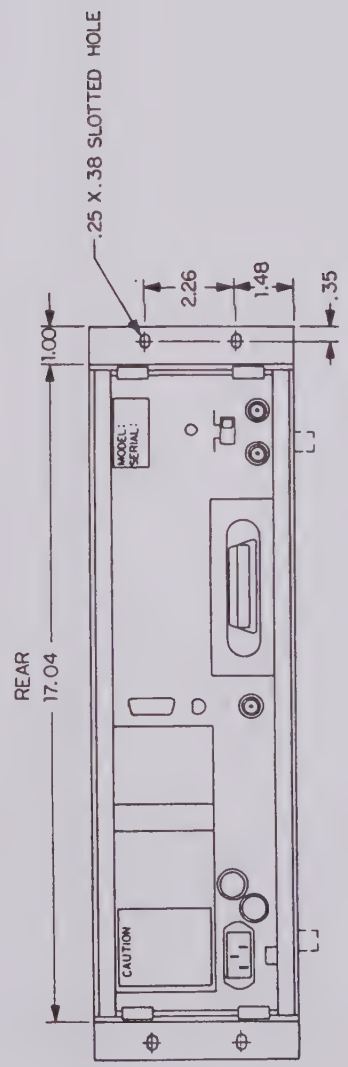


Figure 1

FRONT PANEL

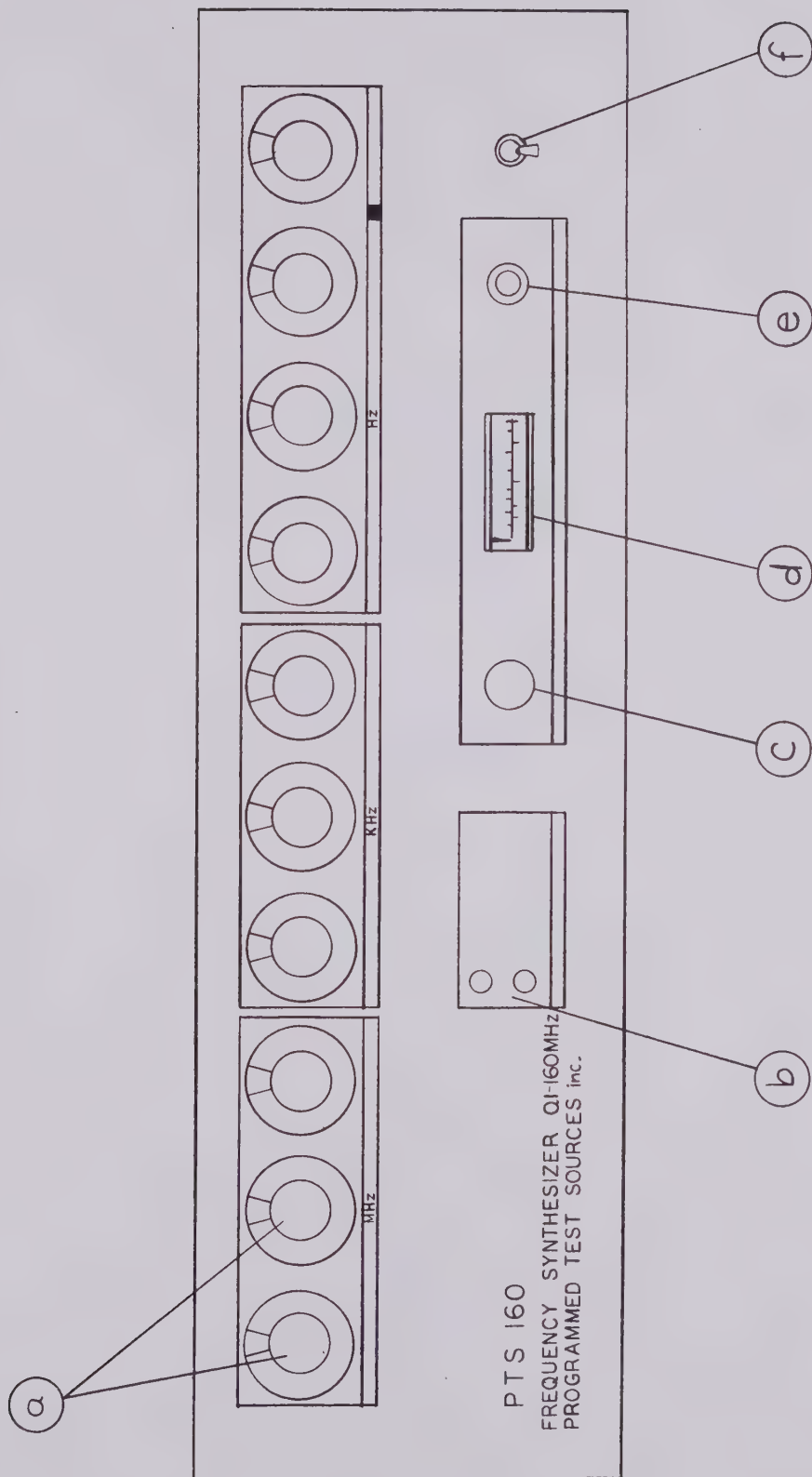


Figure 2

REAR PANEL CONTROLS

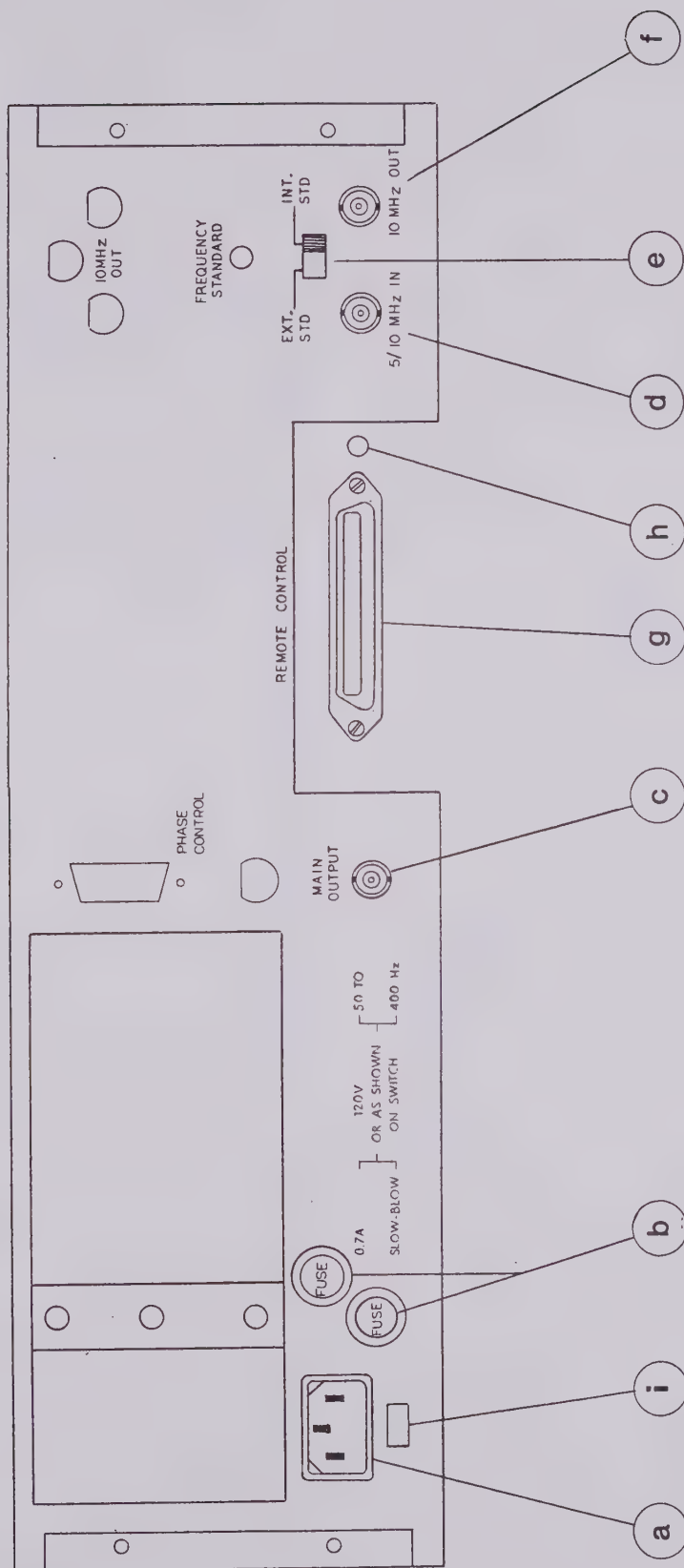


Figure 3

LOCATION OF TEST POINTS
(BOTTOM VIEW OF DECK)

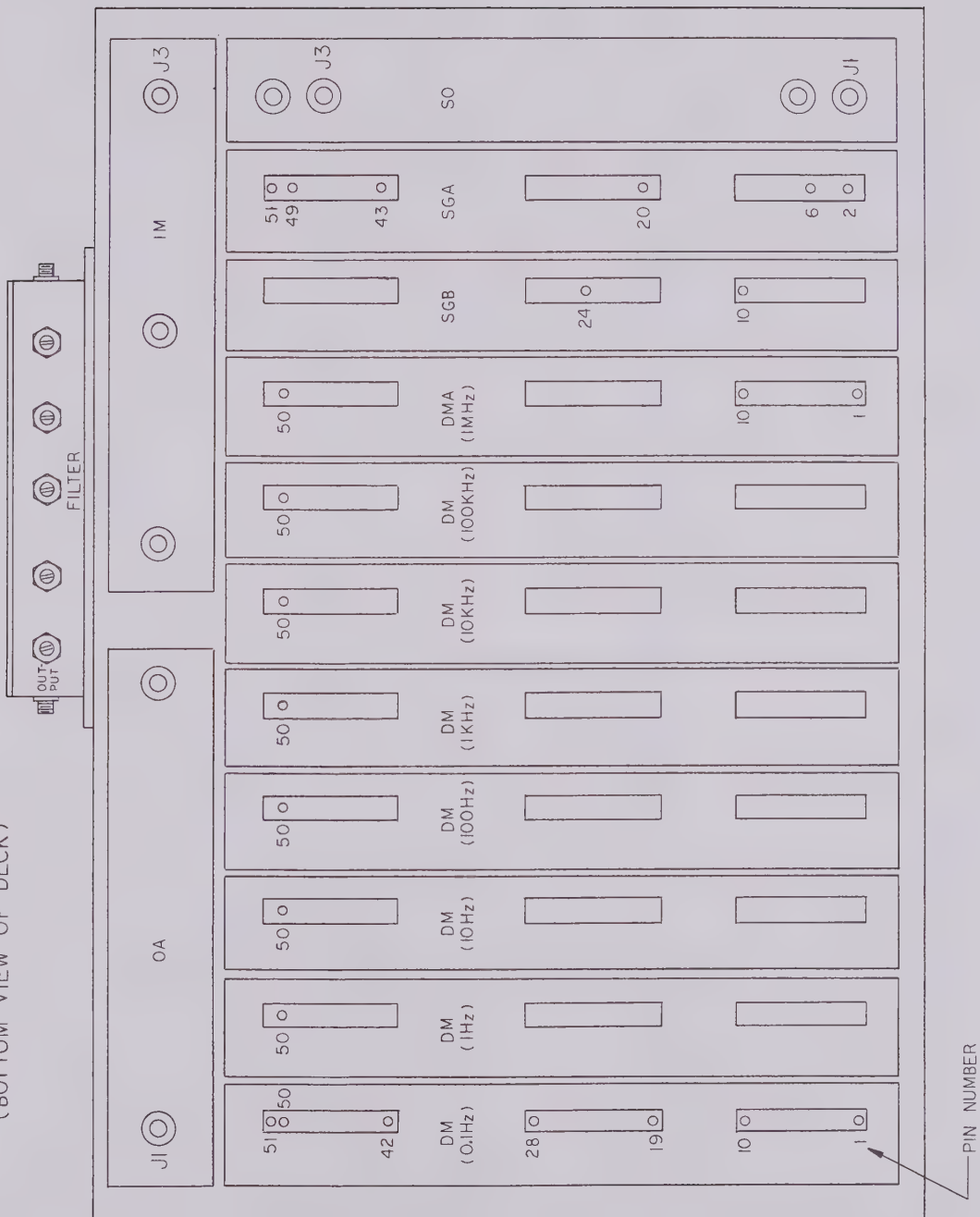


Figure 5

PTS 160 MODULE LOCATION

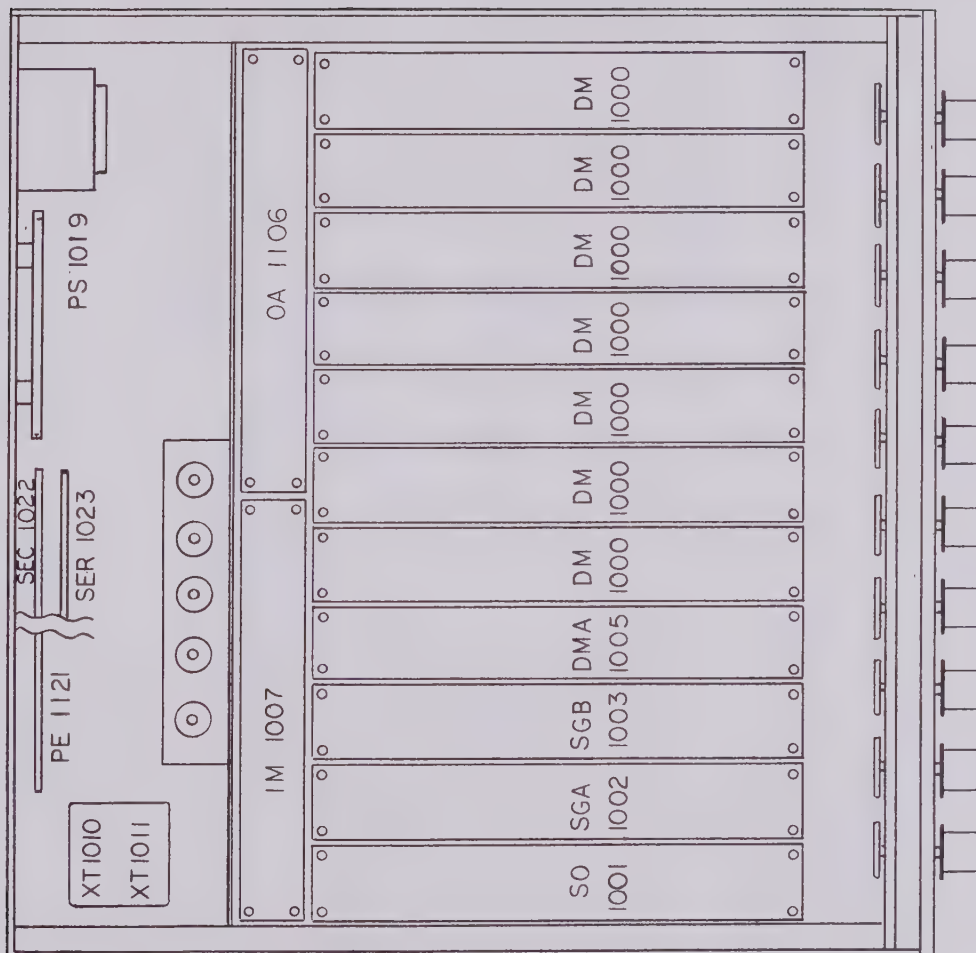
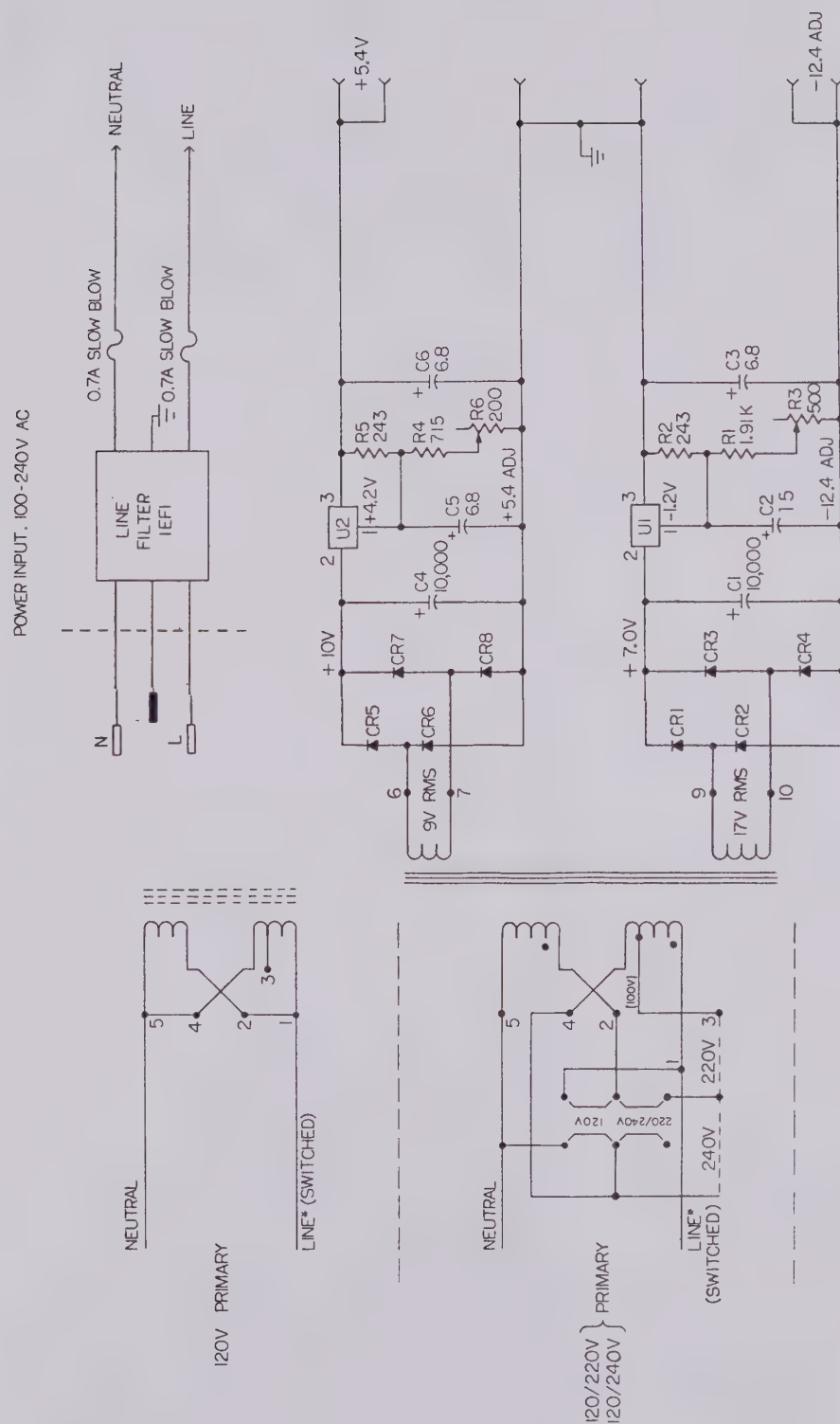


Figure 6

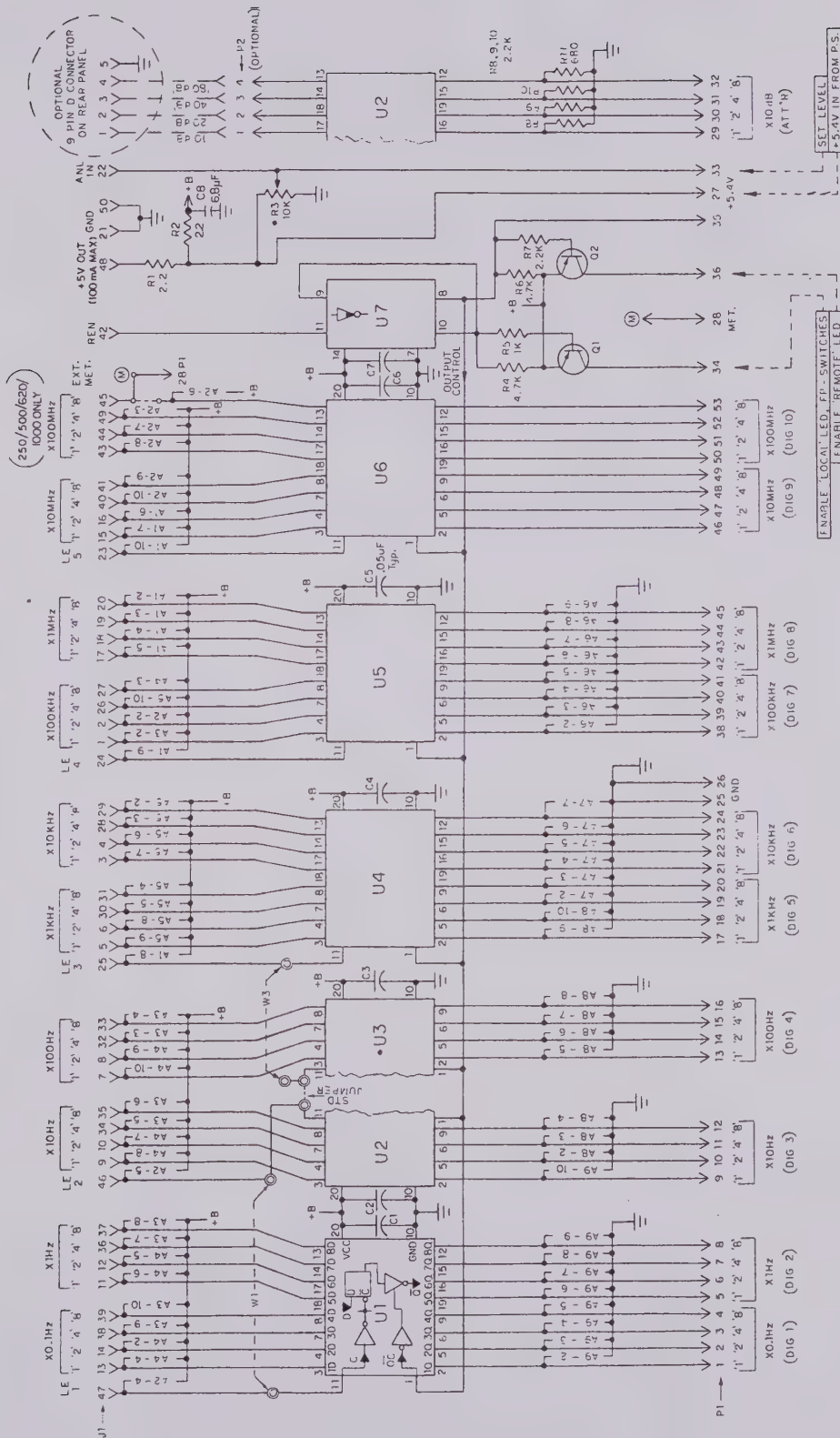


UNLESS OTHERWISE SPECIFIED:
1. RESISTORS ARE IN OHMS (Ω).
2. CAPACITORS ARE IN MICROFARADS (μ F).
3. ALSO VALID FOR: PS 1053

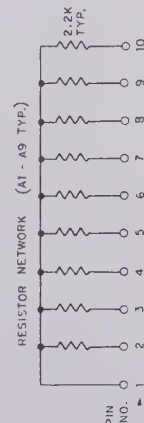
PS-1053	SCHEMATIC
PS 1019	SCHEMATIC

~~X~~ NO SWITCH IN "REMOTE ONLY" UNITS

Figure 7



INTERNAL DIGIT CONTROL



- *NOTES:
- U3 PINS 12, 15, 16, 19 NOT USED
- U3 PINS 13, 14, 17, 18 CONNECTED TO +B.
- R3 OPTIONAL (USED IN REMOTE ONLY UNITS).

Figure 8

GPIB
INTERFACE
SEC 1022
SER 1023
SECTION



PROGRAMMED TEST SOURCES, inc.

Littleton, Massachusetts, USA.

GPIB INTERFACE SECTION

Table of Contents

	Page
Condensed Programming Instructions.....	ii
Introduction.....	1
Functional Overview.....	1
Specifications.....	2
IEEE 488 Interface Function Capability Code.....	2
IEEE 488 Connector Pin Assignments.....	2
Installation.....	3
Setting the Listen Mode.....	3
Setting the Listen Address.....	3
Table 1: Listen Address Switch Settings.....	4
Operation.....	5
Overview.....	5
Initialization.....	5
Programming Instrument Functions.....	6
Table 2: Common ASCII Codes.....	7
GPIB Data Rate and Instrument Switching Time.....	8
Programming Examples.....	9
Notes For PTS 120 Model Instruments.....	11
Service.....	12
Maintenance.....	12
Troubleshooting.....	12
Parts Lists.....	13
Figure 1: SEC 1022 Schematic.....	17
Figure 2: SER 1023 Schematic.....	18
Table 1: Listen Address Switch Settings.....	4
Table 2: Common ASCII Codes.....	7
Figure 1: SEC 1022 Schematic.....	17
Figure 2: SER 1023 Schematic.....	18

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Condensed Programming Instructions

- 1. General:** The SEC-1022/SER-1023 GPIB interface option provides remote control of PTS model 040, 120, 160, 250, 500, 620, 1000 and 3200 synthesizers via the GPIB bus. Frequency and signal output level can be set via bus commands. This option replaces the standard BCD-TTL parallel remote control interface.
- 2. Capability Code:** IEEE 488.1-1987; SH0, AH1, T0, L1, SR0, RL2, PP0, DC0, DT0, C0, E1
- 3. Addressing:** Address switch selectable to any one of 31 standard listen addresses; switch selectable Listen Only or Addressed modes.

- 4. Programming:** **Frequency** - A string starting with letter F (ASCII 70) followed by up to 10 numerals. For PTS models 040 through 1000, the 10 digits specify the 100 MHz through 0.1 Hz positions; for the PTS 3200, the 10 digits specify the 1 GHz through 1 Hz positions. If less than 10 numerals are used, only the least-significant digits are updated (unspecified high order digits are unchanged).

Examples for **PTS 040** through **PTS 1000** (100 MHz thru 0.1 Hz digits):

F101 510 000 0	sets 101.51 MHz
F000 125 400 0	sets 125.4 KHz
F125 400 0	changes 100 KHz and lower digits to 125.4 KHz

Examples for **PTS 3200** (1 GHz through 1 Hz digits):

F2 348 609 000	sets 2.348 609 GHz
F0 101 510 000	sets 101.51 MHz

Signal Level - A string starting with letter A (ASCII 65) followed by 1 or 2 digits representing attenuation in 1 dB steps referenced from full output (+13 dBm, 1V into 50 ohms).

Examples:	A9	sets -9 dB from full output
	A0	sets full output
	A23	sets -23 dB from full output (requires optional 10 dB step attenuator)

Both frequency and signal level data can be combined in any sequence within a single command.

Examples:	F1250000000A6	sets PTS 160 to 125 MHz, -6 dB from full output
	A0F0010000000	sets PTS 3200 to full output, 10 MHz

Other - Go to Local (GTL), also as device-dependent command by transmitting ASCII code 1.

Terminator - All commands must be terminated by LF (ASCII 10) .

- 5. Transfer Rate:** Internally limited to 1 μ second per character for data transfer; internally limited to 20 μ second per transfer command (LF) to allow for instrument switching speed.
- 6. Connector:** IEEE 488 24 pin female connector.

Introduction

The GPIB interface section consists of the SEC-1022 (Serial Control) and SER-1023 (Serial Register) modules. These modules provide the necessary hardware and control logic to remotely program an instrument via the GPIB (General Purpose Interface Bus) in accordance with the ANSI/IEEE Std 488.1-1987.

The SEC and SER modules are unique and may not be interchanged with any other modules in the instrument. The two modules are piggy-backed and interconnected through a connector. Together, the boards are mechanically fastened to the instrument rear panel by four screws. The SEC module faces to the rear and contains a standard 24-pin GPIB connector and a six-position DIP switch for address and listen-mode selection. The SER module connects internally to the rest of the instrument through a single header strip.

Functional Overview

The basic data transfer on the GPIB is bit parallel, byte serial (one byte at a time), under the direction of a GPIB controller. The user typically provides the controller with information on the address of an instrument to be controlled, and any instrument-specific (also called device-dependent) instructions. The controller (or control program) will then generate a string of characters containing the ASCII codes for addressing the instrument and performing the instrument-specific function, and transmit these in conformance with the IEEE 488 timing and handshaking specifications.

A PTS synthesizer equipped with the GPIB interface acts as a **basic listener** device. The standard **LISTEN ONLY** and **ADDRESSED** modes of operation are supported. In the LISTEN ONLY mode, all valid commands are accepted without regard to device address; in the ADDRESSED mode, only commands preceded by the instrument's selectable address are executed.

In addition to LOCAL/REMOTE mode control, PTS's GPIB interface has the capability to perform two synthesizer-specific (or device-dependent) functions through appropriate commands issued over the GPIB: setting the output frequency and setting the output signal level.

SPECIFICATIONS

IEEE 488 Interface Function Capability Code

Code	Description	Capability
SH0	Source Handshake	None
AH1	Acceptor Handshake	Complete
T0	Talk	None
L1	Listen	Basic listener & Listen Only
SR0	Service request	None
RL2	Remote/Local	No local lockout
PP0	Parallel poll	None
DC0	Device Clear	None
DT0	Device Trigger	None
C0	Controller	None
E1	Driver type	Open collector drivers

IEEE 488 Connector Pin Assignments

PIN	SIGNAL	FUNCTION	BUS
1	DIO1	Data Bit 1	data bus
2	DIO2	Data Bit 2	data bus
3	DIO3	Data Bit 3	data bus
4	DIO4	Data Bit 4	data bus
5	EOI	End or Identify	management bus (inactive)
6	DAV	Data Valid	byte transfer bus
7	NRFD	Not Ready For Data	byte transfer bus
8	NDAC	Not Data Accepted	byte transfer bus
9	IFC	Interface Clear	management bus
10	SRQ	Service Request	management bus (inactive)
11	ATN	Attention	management bus
12	SHIELD	Shield	
13	DIO5	Data Bit 5	data bus
14	DIO6	Data Bit 6	data bus
15	DIO7	Data Bit 7	data bus
16	DIO8	Data Bit 8	data bus
17	REN	Remote Enable	management bus
18	GND	Ground return for DAV	
19	GND	Ground return for NRFD	
20	GND	Ground return for NDAC	
21	GND	Ground return for IFC	
22	GND	Ground return for SRQ	
23	GND	Ground return for ATN	
24	GND	Logical ground	

All functions are negative true, TTL logic compatible.

Levels: Low +0.8V max
 High +2.0V min

Installation

For remote synthesizer operation, connection to an operating GPIB bus and selection of a valid listen address are required. Connect the GPIB bus cable to the 24-pin GPIB connector located on the instrument rear panel. Tighten the connector interlocking screws to insure that the cable and connector are properly and fully engaged.

Setting the Listen Mode

The listen mode (LISTEN ONLY or ADDRESSED) is selected via switch 6 on the six-pin DIP switch located next to the GPIB connector. Set switch 6 (labelled **LISTEN ONLY** and **ADDR'D**) to the desired listen mode according to the labels. (See the **Operation** section for a discussion of the LISTEN ONLY and ADDRESSED listen modes.)

If it is necessary to change the listen mode, the instrument's power should be turned off, the listen mode changed, and then power reapplied. This will insure that the interface is properly reset to the new listen mode.

Setting the Listen Address

The listen address is selected via switches 1 through 5 on the six-pin DIP switch located next to the GPIB connector. Set switches 1 through 5 (labelled **A1** through **A5**) to the appropriate listen address according to **Table 1: Listen Address Switch Settings** (page 4). Note that address 31 is reserved for the "UNLISTEN" command, and must **not** be used as a Listen address. Be certain that the LISTEN ADDRESS selected is not assigned to any other instrument connected to the GPIB.

Table 1: Listen Address Switch Settings

User-Selected ADDRESS (5 bits)	Internal MLA (7 bits)	Equivalent ASCII Character (7 bits)	Switch Settings				
			A5	A4	A3	A2	A1
0	32	SP	0	0	0	0	0
1	33	!	0	0	0	0	1
2	34	"	0	0	0	1	0
3	35	#	0	0	0	1	1
4	36	\$	0	0	1	0	0
5	37	%	0	0	1	0	1
6	38	&	0	0	1	1	0
7	39	'	0	0	1	1	1
8	40	(	0	1	0	0	0
9	41	)	0	1	0	0	1
10	42	*	0	1	0	1	0
11	43	+	0	1	0	1	1
12	44	,	0	1	1	0	0
13	45	-	0	1	1	0	1
14	46	.	0	1	1	1	0
15	47	/	0	1	1	1	1
16	48	0	1	0	0	0	0
17	49	1	1	0	0	0	1
18	50	2	1	0	0	1	0
19	51	3	1	0	0	1	1
20	52	4	1	0	1	0	0
21	53	5	1	0	1	0	1
22	54	6	1	0	1	1	0
23	55	7	1	0	1	1	1
24	56	8	1	1	0	0	0
25	57	9	1	1	0	0	1
26	58	:	1	1	0	1	0
27	59	;	1	1	0	1	1
28	60	<	1	1	1	0	0
29	61	=	1	1	1	0	1
30	62	>	1	1	1	1	0
31	63	?	RESERVED FOR UNLISTEN COMMAND				

NOTE: Address 31 is reserved for the "UNLISTEN" command, and must **not** be used as a Listen address.

Operation

Overview

The GPIB interface supports two listen modes of operation:

- (a) An "addressed" mode where only "addressed commands" (AC-class) and "device-dependent" commands (DD-class), preceded by the instrument's selectable listen address, are executed.
- (b) A "LISTEN ONLY" mode where any valid command is carried out without regard to address.

Only one listen mode is active at any one time, with the active mode selected during the system setup procedure.

In either listen mode, a message or command string must be transferred to the synthesizer to effect some action. In general, the command string must specify:

Instrument address	(if in ADDRESSED mode)
Code letter for desired function	
Numerical value for desired function	(if any)
Command terminator	

Initialization

For proper operation of the GPIB interface, both an initializing frequency setting command and an initializing level (amplitude) setting command must be issued. The initializing frequency command must contain settings for all 10 digits (letter F followed by 10 numerals). The initializing level command must contain 1 digit (letter A followed by 1 numeral); for instruments equipped with the optional 10 dB-step attenuator, the initializing level command must contain 2 digits (letter A followed by 2 numerals). Subsequent frequency setting commands may contain less than 10 numerals to update only less significant digits of the frequency; for instruments with the optional 10 dB-step attenuator, subsequent level setting commands may contain only 1 numeral to update the less significant digit of the amplitude setting.

(Note: On instruments with front panel controls, the front panel level control must be in the fully counter-clockwise, or disconnected, position for proper operation of the GPIB amplitude function.)

Programming Instrument Functions

The PTS GPIB interface will respond to the following "ADDRESS" (AD-class) and "ADDRESSED COMMAND" (AC-class) interface messages (i.e., commands sent with ATN true):

<u>Mnemonic</u>	<u>Command</u>	<u>Class</u>	<u>ASCII Char.</u>	<u>Decimal Value</u>	<u>Resulting Action</u>
MLA	My Listen Address	AD	SP thru >	32 thru 62	Device listens and goes remote on 1st numeric character.
UNL	Unlisten	AD	?	63	Device unlistens, but stays in remote.
GTL	Go to Local	AC	SOH	1	Returns to local, if in remote; no action if in local.

The PTS GPIB interface will respond to the following "DEVICE-DEPENDENT" (DD class) messages (i.e., commands sent with ATN false):

<u>Function</u>	<u>Command String*</u>	<u>Notes</u>
Set frequency, all 10 digits	F <10 numerals> LF	1st numeral is MSD
Set frequency, n digits	F < n numerals> LF	only n least-significant digits changed; other digits unchanged
Set output level in -dB, 10 dB range in 1 dB steps	A <1 numeral> LF	output level = - 1 dB x numeral, referenced from full output
Set output level in -dB, 99 dB range in 1 dB steps (requires optional 10 dB step attenuator)	A <2 numerals> LF	output level = -10 dB x 1st numeral + -1 dB x 2nd numeral, referenced from full output
Return to local mode	SOH LF	GTL also implemented as DD command

*where "<>" notation brackets material replaced by user-data; command string coded using ASCII code (see **Table 2: Common ASCII Codes**).

NOTES: (1) When fewer than 10 digits are transmitted with the frequency setting command, only least significant digits are updated. Any unspecified digits retain their value from the previous frequency setting command.

(NOTES continued)

(2) If front panel controls are present, the front panel level control must be in the fully counter-clockwise position for proper operation of the GPIB amplitude function.

(3) Each command must be terminated with a **LF** (linefeed); this terminator character causes internal transfer of the data and command execution.

(4) Multiple commands **may** be transmitted in the same command string and followed by a single command terminator., e.g., the string "F1234567890A0" transmitted and terminated with **LF** (linefeed) sets both signal frequency and level.

Table 2: Common ASCII Codes

<u>ASCII Character</u>	<u>ASCII Code</u>
GTL	1
SOH	1
LF	10
0	48
1	49
2	50
3	51
4	52
5	53
6	54
7	55
8	56
9	57
A	65
F	70

NOTE: Any ASCII characters not listed in this table are ignored by the GPIB interface. For readability, commas and decimal points may be freely inserted into command strings transmitted to the interface; these characters will be ignored.

GPIB Data Rate and Instrument Switching Time

The IEEE 488 standard allows a maximum **data rate** over the interface bus of 1,000,000 bytes per second. The PTS GPIB interface is capable of operating at this speed during transfer of a command string, with an internal transfer rate of 1 μ second per character received.

However, after receiving a command string terminator character (LF), the instrument's normal **switching time** for the received command must elapse prior to transfer of the next command. For example, after specifying an output frequency switch, between 5 and 20 μ seconds switching time is required before the output signal frequency change is effected (dependent on the digit switched; refer to specifications in the **System Section** of this manual for detailed information on instrument switching times). Therefore, the GPIB interface also includes an internal time delay of 20 μ second per transfer command to insure that the maximum switching time is observed.

Programming Examples

Example 1: Assume we want to set a PTS 160 instrument at address 13 to a frequency of 123.4567890 MHz, with signal level of -3 dB referenced from full output (+13 dBm)

The complete ASCII string transmitted by the controller to the instrument would be:

	ASCII Data	ASCII Char	ATN	Function	Command Class
Byte 1:	45	-	TRUE	MLA	AD
Byte 2:	70	F	FALSE	DAB 1	DD
Byte 3:	49	1	FALSE	DAB 2	DD
Byte 4:	50	2	FALSE	DAB 3	DD
Byte 5:	51	3	FALSE	DAB 4	DD
Byte 6:	52	4	FALSE	DAB 5	DD
Byte 7:	53	5	FALSE	DAB 6	DD
Byte 8:	54	6	FALSE	DAB 7	DD
Byte 9:	55	7	FALSE	DAB 8	DD
Byte 10:	56	8	FALSE	DAB 9	DD
Byte 11:	57	9	FALSE	DAB 10	DD
Byte 12:	48	0	FALSE	DAB 11	DD
Byte 13:	10	LF	FALSE	DAB 12	DD
Byte 14:	65	A	FALSE	DAB 13	DD
Byte 15:	51	3	FALSE	DAB 14	DD
Byte 16:	10	LF	FALSE	DAB 15	DD
Byte 17:	63	?	TRUE	UNL	AD

Management of the ATN line is typically left up to the controller or controlling software, not the end-user directly. Using a computer controller, the actual information transmitted is much more straightforward, as the following examples demonstrate.

Example 2: Example 1 implemented in BASIC on a PET computer/controller would require these program lines:

```
10      OPEN 200,13
20      PRINT#200, "F1234567890"
30      PRINT#200, "A3"
```

A subsequent change in level to 0 dB attenuation from full output (+13 dBm) would be commanded as follows:

```
40      PRINT#200, "A0"
```


A return to local control would be commanded as follows:

```
50      PRINT#200, CHR$(1)
```

NOTE: In this example with the PET/BASIC language, the PRINT#200 statements automatically generate the appropriate MLA byte, append the terminator character LF, and transmit the UNL byte.

Example 3: Example 1 implemented in BASICA on an IBM-compatible* computer with the National Instruments Corp. GPIB-PC** package would require these program lines (the GPIB-PC talk address is 64 or ASCII @):

```
10      CMD$="?@-"      'REM: UNL MTA MLA
20      CALL IBCMD(BRD%,CMD$)
30      CMD$="F1234567890" + CHR$(10)
40      CALL IBWRT(BRD%,CMD$)
50      CMD$="A3" + CHR$(10)
60      CALL IBWRT(BRD%,CMD$)
70      CMD$="-?"      'REM: UNT UNL
80      CALL IBCMD(BRD%,CMD$)
```

Example 4: Assume we want to set a PTS 3200 instrument at address 13 to a frequency of 1.234567890 GHz, with signal level of -3 dB referenced from full output (+13 dBm). As in example 3, control with the National Instruments Corp. GPIB-PC** package would require these program lines (the GPIB-PC talk address is 64 or ASCII @):

```
10      CMD$="?@-"      'REM: UNL MTA MLA
20      CALL IBCMD(BRD%,CMD$)
30      CMD$="F1234567890" + CHR$(10)
40      CALL IBWRT(BRD%,CMD$)
50      CMD$="A3" + CHR$(10)
60      CALL IBWRT(BRD%,CMD$)
70      CMD$="-?"      'REM: UNT UNL
80      CALL IBCMD(BRD%,CMD$)
```

*IBM is a trademark of International Business Machines Corp.

**GPIB-PC is a trademark of National Instruments Corp.

NOTES FOR PTS 120 MODEL INSTRUMENTS

Frequency Command

The GPIB interface for the PTS 120 operates from a base or offset of 90 MHz. Therefore, for programming the 90, 100 and 110 MHz steps, only the offset from 90 MHz should be coded, as follows:

Actual Frequency	Code for 10 MHz Step
90 MHz	00
100 MHz	01
110 MHz	02

Examples:

Desired Frequency	GPIB Command
90.1250030 MHz	F0001250030
100.1250030MHz	F0101250030
110.1250030 MHz	F0201250030
114.1250030 MHz	F0241250030

Level Command

Since the maximum output of the PTS 120 is +10 dBm, there are only seven 1 dB steps in instruments without the optional 10 dB step attenuator.

Examples:

Desired Level	GPIB Command
10 dBm	A03
9 dBm	A04
.	.
.	.
.	.
4 dBm	A09

SERVICE

Maintenance

No preventive maintenance is required for the GPIB interface section modules. The presence of a proper output signal with frequency and signal level programmed over the GPIB indicates that the modules are operating properly.

Troubleshooting

If frequency or output level do not operate properly when programmed over the GPIB, return the instrument to local control and verify that the instrument operates correctly. If the instrument does not operate correctly under local control, another module is faulty; follow the **System Section** manual Troubleshooting procedure to locate the faulty module.

If the instrument does operate correctly under local control, either the remote programming commands are incorrect or the GPIB interface is faulty. **A careful and thorough examination of the programming procedure should be undertaken to insure that valid commands are being transmitted; the vast majority of interface-related problems arise because of programming errors.** Insure that a valid address has been assigned to the instrument, and insure that a command terminator (LF) is being transmitted after **each** command. Note that most GPIB software packages do **not** automatically append terminator characters; they must be appended by the user.

Repair of faulty interface modules in the field is not possible; a faulty module must be exchanged and sent to the factory for repair.

SEC-1022 Parts List

Schematic Design	Description	PTS P/N
CAPACITORS		
C1	47 μ F, El. Tant. 6V	30-5102
C2	10nF, 80/20%, 50V, 25V	23-0103
C3	100pF, 5%, 500V, N750	21-0101
C4	100pF, 5%, 500V, N750	21-0101
C5	1nF, 10%, 500V, X5F	22-0102
C6	6.8 μ F, El. Tant. 16V	30-5101
C7	10nF, 80/20%, 50V, Z5V	23-0103
C8	50nF, 80/20%, 50V, Z5V	23-0503
C9	50nF, 80/20%, 50V, Z5V	23-0503
C10	50nF, 80/20%, 50V, Z5V	23-0503
C11	50nF, 80/20%, 50V, Z5V	23-0503
C12	50nF, 80/20%, 50V, Z5V	23-0503
C13	50nF, 80/20%, 50V, Z5V	23-0503
DIODES		
CR1	LED, green	88-4955
CONNECTORS		
J1	24 contact, PC mount	78-1024
J2	5 contact, receptacle	79-1005
P1	header strip, 20 contacts	79-1002
TRANSISTORS		
Q1	2N2905	42-2905
Q2	2N2905	42-2905
RESISTORS		
A1	Resistor network, 28 resistors	66-5001
R5	2.2, 5%, $\frac{1}{4}$ W	11-1220
R12	4.7K, 5%, $\frac{1}{4}$ W	11-0472
R16	100, 5%, $\frac{1}{4}$ W	11-0101
R18	1.5K, 5%, $\frac{1}{4}$ W	11-0152
R19	150, 5%, $\frac{1}{4}$ W	11-0151
R20	4.7K, 5%, $\frac{1}{4}$ W	11-0472
R21	2.2K, 5%, $\frac{1}{4}$ W	11-0222
R22	1K, 5%, $\frac{1}{4}$ W	11-0102
R23	2.2, 5%, $\frac{1}{4}$ W	11-1220
R24	2.2K, 5%, $\frac{1}{4}$ W	11-0222
R29	330, 5%, $\frac{1}{4}$ W	11-0331
R42	4.7K, 5%, $\frac{1}{4}$ W	11-0472
R43	220, 5%, $\frac{1}{4}$ W	11-0221
R44	4.7K, 5%, $\frac{1}{4}$ W	11-0472
R45	6.8K, 5%, $\frac{1}{4}$ W	11-0682
R46	10K, 5%, $\frac{1}{4}$ W	11-0103
R47	6.8K, 5%, $\frac{1}{4}$ W	11-0682

SEC-1022 Parts List (continued)

Schematic Design	Description	PTS P/N
RESISTORS (cont.)		
R48	15K, 5%, 1/4W	11-0153
R49	1.5K, 5%, 1/4W	11-0152
R50	22K, 5%, 1/4W	11-0223
R51	4.7K, 5%, 1/4W	11-0472
R52	4.7K, 5%, 1/4W	11-0472
R53	4.7K, 5%, 1/4W	11-0472
R54	4.7K, 5%, 1/4W	11-0472
R55	4.7K, 5%, 1/4W	11-0472
R56	4.7K, 5%, 1/4W	11-0472
SWITCHES		
S1-S6	6 PST DIP	87-1008
INTEGRATED CIRCUITS		
U1	74LS08	63-0008
U2	93L24	61-0024
U3	74LS04	63-0004
U4	74LS14	63-0014
U5	74LS21	63-0021
U6	74LS21	63-0021
U7	74LS14	63-0014
U8	74LS107	63-0107
U9	74LS04	63-0004
U10	74LS30	63-0030
U11	93L24	61-5024
U12	74LS21	63-0021
U13	7438	60-0038
U14	74LS21	63-0021
U15	74LS05	63-0005
U16	74LS11	63-0011
U17	74LS51	63-0051
U18	74LS123	63-0123
U19	74LS112	63-0112
U20	74LS00	63-0000
U21	555	64-0555

SER-1023 Parts List

Schematic Design	Description	PTS P/N
CAPACITORS		
C1	6.8 μ F, El. Tant. 16V	30-5101
C2	6.8 μ F, El. Tant., 16V	30-5101
C3	50nF, 80/20%, 50V, Z5V	23-0503
C4	50nF, 80/20%, 50V, Z5V	23-0503
C5	50nF, 80/20%, 50V, Z5V	23-0503
C6	50nF, 80/20%, 50V, Z5V	23-0503
CONNECTORS		
J1	Connector strip, female, 20 cont.	79-1004
P1	Header strip, 25 contacts	79-1003
	Header strip, 25 contacts	79-1003
RESISTORS		
R1-R32	2.2K Ω , 5%, 1/4W (32x)	11-0222
R33-R34	2.2 Ω , 5%, 1/4W (2x)	11-1220
R35	1K Ω , 5%, 1/4W	11-0102
R36	1K Ω , 5%, 1/4W	11-0102
R37	1K Ω , 10%, .75W	17-5104
R38	100K Ω , 5%, 1/4W	11-0104
R39	4.7K Ω , 5%, 1/4W	11-0472
R40	2K Ω , 5%, 1/4W	11-0202
R41	1.21K Ω , 1%	14-5110
R42	845 Ω , 1%	14-5124
R43	634 Ω , 1%	14-5108
R44	470 Ω , 5%	11-0471
R45	365 Ω , 1%	14-5107
R46	301 Ω , 1%	14-5106
R47	243 Ω , 1%	14-5105
R48	2.2K Ω , 5%, 1/4W	11-0222
R49	2.2K Ω , 5%, 1/4W	11-0222
R50	2.2K Ω , 5%, 1/4W	11-0222
R51	2.2K Ω , 5%, 1/4W	11-0222
R52-R54	2.2K Ω , 5%, 1/4W	11-0222
R55	680 Ω , 5%, 1/4W	11-0681

GPIB

SER-1023 Parts List (continued)

Schematic Design	Description	PTS P/N
INTEGRATED CIRCUITS		
U1	74LS74	63-0074
U2	74LS175	63-0175
U3	74LS175	63-0175
U4	74LS273	63-0273
U5	74LS74	63-0074
U6	74LS174	63-0174
U7	74HCT173	61-5031
U8	74LS145	63-0145
U9	74HCT173	61-5031
U10	74HCT173	61-5031
U11	74LS164	63-0164
U12	74HCT173	61-5031
U13	74LS174	63-0174
U14	74LS164	63-0164
U15	74HCT173	61-5031
U16A (160 MHz)	74184	60-0184
or		
U16B (250 MHz)	74HCT173	61-5031
U17	74HCT173	61-5031
U18	74HCT173	61-5031
U19	74LS164	63-0164
U20	74HCT173	61-5031
U21	74HCT173	61-5031
U22	74LS164	63-0164
U23	74HCT173	61-5031
U24	74HCT173	61-5031

[illegible]

SER-1023 Schematic

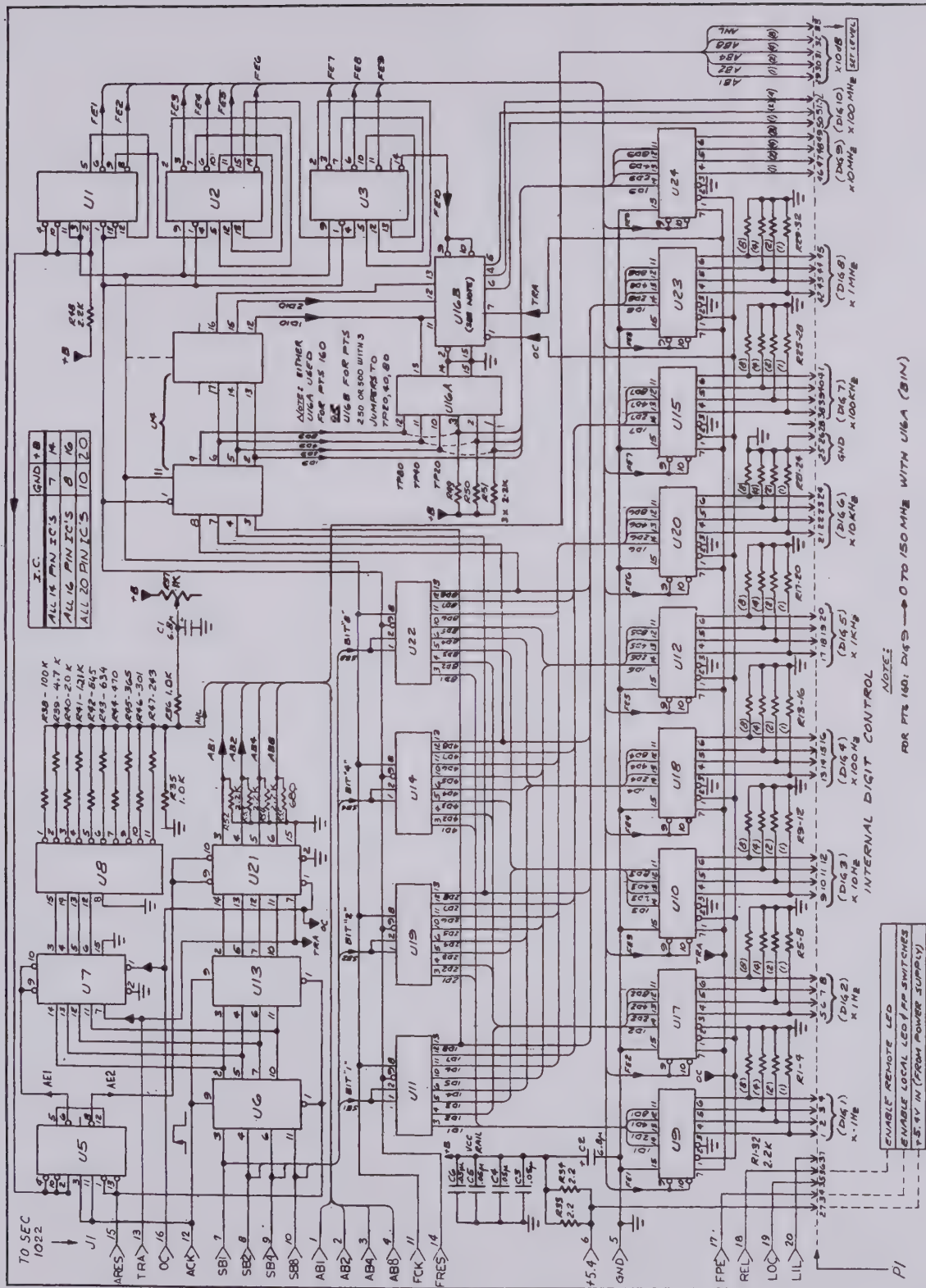


Figure 2

